

MOSCOW SUBWAY WIBOX ANTENNA WITH CISCO ROUTERS INSTALLATION

One of our customers faced the problem of increasing the real throughput in the communication in the Moscow subway. They needed connection between a moving train and stationary points in a tunnel, with NLOS conditions and roaming between APs in the tunnel. The system is based on the CISCO 5 GHz AccessPoint of Cisco Aironet 3600 Series AP units and WIBOX PA D4M5-20HVX MIMO 4x4 directional antennas. The installation has been done at the standard of 802.11n on MIMO 4x4 technology (exactly with 3SS + one stream for a beamforming).

One side of the link was located in the train (Pic. 1 And Pic. 2), the other point was placed in a stationary point in the subway tunnel (Pic. 3 and Pic. 4).



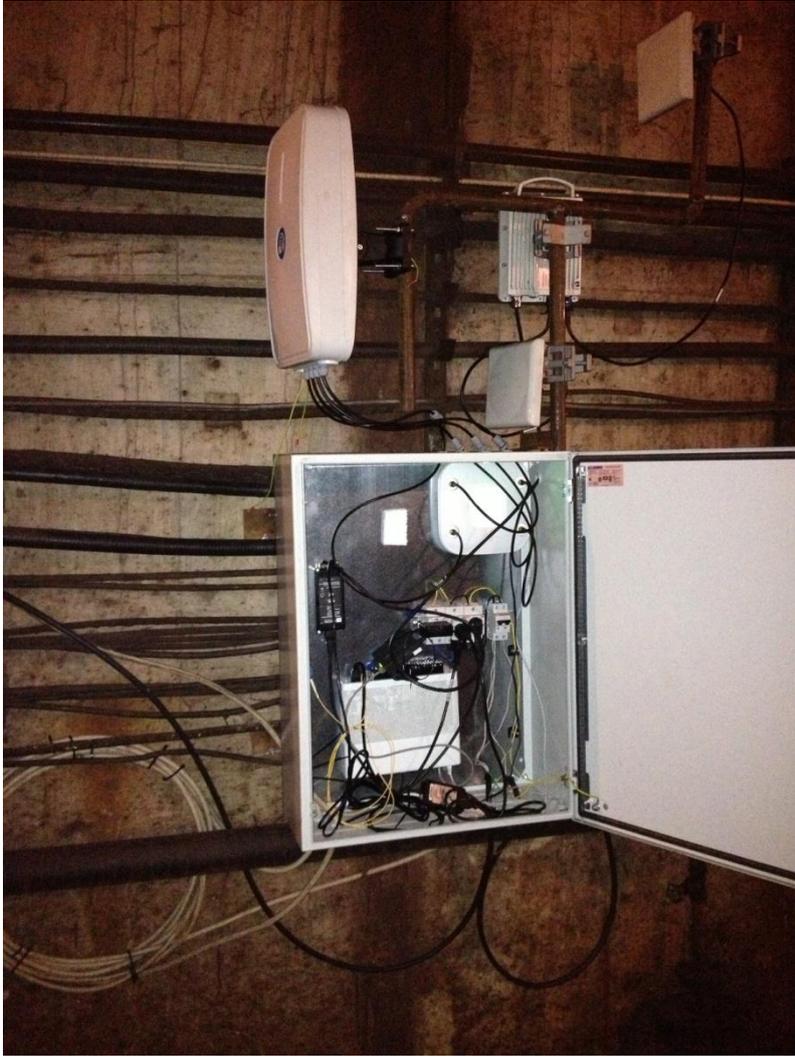
Pic. 1 The moving Access Point of WiBOX PA D4M5-20HVX MIMO 4x4 directional antenna and Cisco router installed inside.



Pic. 2 WiBOX PA D4M5-20HVX MIMO 4x4 directional antenna and Cisco router installed inside the train.



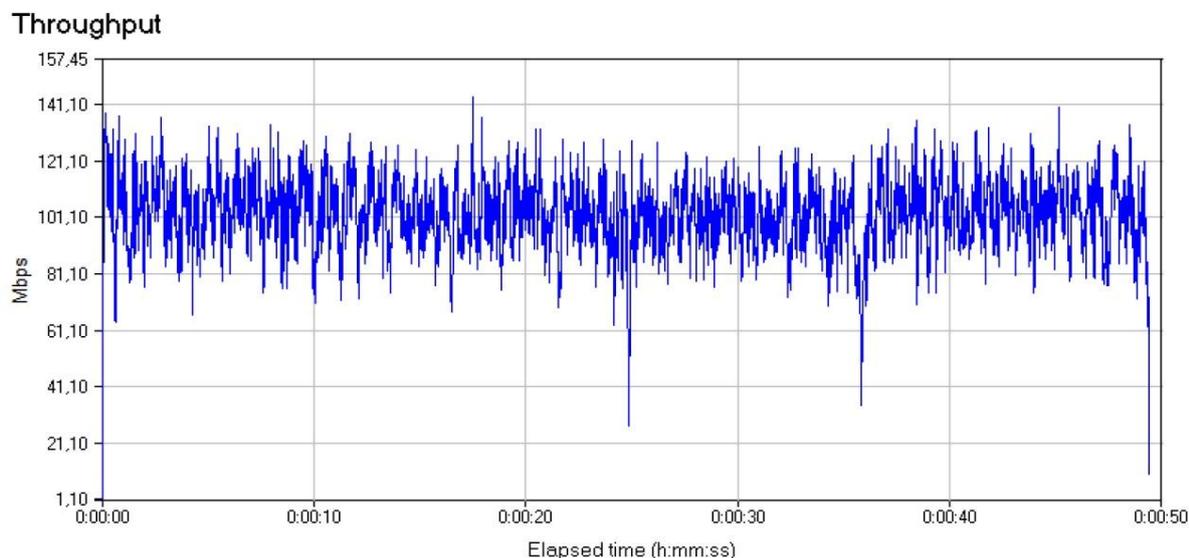
Pic. 3 Stationary point with WiBOX PA D4M5-20HVX MIMO 4x4 directional antenna and Cisco router installed inside.



Pic 4. Stationary point with WiBOX PA D4M5-20HVX MIMO 4x4 directional antenna and Cisco router installed inside.

The goal was to get the maximum throughput between a moving point in the train and stationary points in the metro. In the tunnel there was a necessity to use the most directional antennas as it's possible. The choice was WiBOX PA D4M5-20HVX MIMO 4x4 directional antenna. It's antenna based on the PTFE microstrip substrate, so it allows to minimize the antenna dimensions (4x4 antenna is housed in 26 x 48 [cm] enclosure, and gives stable parameters in a wide frequency range. As written above CISCO Aironet 3600 offers 3 spatial streams + one connector for beamforming. In this case there is possibility to achieve theoretical max. throughput of 450Mbps. Single polarity applications cannot be used in this location because of many reflections from the tunnel walls, here was necessary a good solution which CISCO brings to their customers. CISCO engineers decided to use 40 MHz channels for this application, the MCS possible to use in given conditions was max 23 (max for 3SS). The distance for the test (between moving train and a point inside the subway) was max. 360m, the speed of moving train was 75 km/h (~47mph), what was additional disadvantage for the link and have influence for the final result. In that installation there were set up 3 Access Points on the train way, the distances between APs was 260m and 360m. The standard of 802.11n was designed for stationary points only, the test is some of an experimental 802.11n application, finally with unexpected good result.

The maximum stable TCP transfer achieved was over 100Mbps, without a big changes (Pic. 5).



Pic. 5 The graph of dependency of throughput in relation to time in the installation of CISCO Aironet 3600 with WiBOX PA D4M5-20HVX MIMO 4x4 directional antenna, in Moscow metro.

As it's seen from the Pic. 5 the TCP transfer is stable and the average level is over 100Mbps, what is very good result taking into consideration conditions where the test had a place. The train was moving with the speed of 75km/h (~ 47mph). Maximum theoretical throughput (for two stationary points) is 450 Mbps on the MCS23, see the article <http://www.wireless-instruments.com/en/14/802-11n-standard-essentials-advantages-and-changes.html>. MIMO 4x4 is the best solution (of 802.11n standard) for the places where is a lot of reflection obstacles. It carries 4 different spatial streams, so it requires antenna 4x4 to maximalize the streams separation. Strong multipath effect needs a good radio to take advantages of this fact (in SISO applications it would decrease signal). The main point is the separation between connectors in the antenna and in a result the highest possible level of separation between spatial streams to avoid big interferences. The antenna of WiBOX PA D4M5-20HVX <http://www.wireless-instruments.com/en/produkty/15/56/antennas-5-ghz/mimo/directional/wibox-pa-d4m5-20hvx.html> offers 32 dBi of port-to-port isolation. The antenna is predicted to work with MIMO 4x4 or with „lower” versions of MIMO technology. In CISCO Aironet 3600 we face with the MIMO 3x3 technology + one connector for the beamforming, what is the technology for improving the signal quality, not improving the throughput. For this application there are also needed antennas 4x4.

Another interesting thing is the way to get the continuity and stability in the throughput in roam from one base station to the next one. It's possible due to CCKM (Cisco Centralized Key Management) which allows for fast roaming. In described installation three WiBOXes PA D4M5-20HVX with CISCO Aironet 3600 were located in the tunnel one next to another. As the train was moving, the conditions were changing, there was also situations when there was NLOS conditions, which shows the advantages of MIMO technology.

All the test results as well as the photos have been provided by CISCO Engineers from Moscow, we thank a lot for the common work.